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A geographic distribution database of the Neotropical cassava whitefly complex (Hemiptera, Aleyrodidae) and their associated parasitoids and hyperparasitoids (Hymenoptera)

Aymer Andrés Vásquez-Ordóñez[1], Nicolas A. Hazzi[1,2], David Escobar-Prieto[2], Dario Paz-Jojoa[3], Soroush Parsa[1,4]

1 *CIAT, Centro Internacional de Agricultura Tropical (CIAT), Apartado Aéreo, 6713 Cali, Colombia* **2** *Sección de Entomología, Programa Académico de Biología, Universidad del Valle, Apartado Aéreo, 25360 Cali, Colombia* **3** *Departamento de Biología, Universidad de Nariño, Apartado Aéreo, 1175 Pasto, Colombia* **4** *UC Davis Chile Life Sciences Innovation Center, Andrés Bello 2299 No. 1102, Providencia, Santiago, Chile*

Corresponding author: *Aymer Andrés Vásquez-Ordóñez* (a.a.vasquez@cgiar.org)

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Abstract

Whiteflies (Hemiptera, Aleyrodidae) are represented by more than 1,500 herbivorous species around the world. Some of them are notorious pests of cassava (*Manihot esculenta*), a primary food crop in the tropics. Particularly destructive is a complex of Neotropical cassava whiteflies whose distribution remains restricted to their native range. Despite their importance, neither their distribution, nor that of their associated parasitoids, is well documented. This paper therefore reports observational and specimen-based occurrence records of Neotropical cassava whiteflies and their associated parasitoids and hyperparasitoids. The dataset consists of 1,311 distribution records documented by the International Center for Tropical Agriculture (CIAT) between 1975 and 2012. The specimens are held at CIAT's Arthropod Reference Collection (CIATARC, Cali, Colombia). Eleven species of whiteflies, 14 species of parasitoids and one species of hyperparasitoids are reported. Approximately 66% of the whitefly records belong to *Aleurotrachelus socialis* and 16% to *Bemisia tuberculata*. The parasitoids with most records are *Encarsia hispida*, *Amitus macgowni* and *E. bellottii* for *A. socialis*; and *E. sophia* for *B. tuberculata*. The complete dataset is available in Darwin Core Archive format via the Global Biodiversity Information Facility (GBIF).

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Keywords
Aleyrodid, *Manihot esculenta*, hymenopterous parasitoids, hyperparasitism, tritrophic interaction, CIAT's Arthropod Reference Collection (CIATARC)

Introduction

Whiteflies (Hemiptera, Aleyrodidae) are represented by more than 1,500 herbivorous species around the world (Hodges and Evans 2005, Evans 2007, 2008). Some of them are notorious pests of cassava (*Manihot esculenta*), a primary food crop in the tropics (Lebot 2009). Particularly destructive is a complex of Neotropical cassava whiteflies whose distribution remains restricted to their native range (Trujillo et al. 2004, Bellotti et al 2005). Despite their importance, neither their distribution, nor that of their associated parasitoids, is well documented (Evans 2008, Aliaga 2012, da Silva Alonso et al. 2012, Pietrowski et al 2014, Silva et al. 2014, Plantwise 2015 and Global Biodiversity Information Facility 2015). This paper therefore reports observational and specimen-based occurrence records of Neotropical cassava whiteflies and their associated parasitoids and hyperparasitoids. The dataset consists of 1,311 distribution records documented by the International Center for Tropical Agriculture (CIAT).

Data published through GBIF

http://www.gbif.org/dataset/c6f4c2de-3b71-4ebd-9c98-c21537548f07

Project details

Project title: Management of RTB Critical Pest and Diseases under Changing Climates, through Risk Assessment, Surveillance and Modeling.

Project personnel: Aymer Andrés Vásquez-Ordóñez (Data Manager, Data Publisher), Nicolas A. Hazzi (Data Manager, Data Publisher), Juan David Escobar-Prieto (Data Manager, Data Publisher), Dario Paz-Jojoa (Data Manager, Data Publisher), Rodrigo Zúñiga (Data Manager), Soroush Parsa (Principal Investigator, Data Publisher).

Whiteflies and parasitoids collectors: Collectors who have more than 30 records include: Bernardo Arias, Jose A. Castillo, Claudia M. Holguin, José María Guerrero B., Gerardino Perez Francisco Rendon and Harold Trujillo.

Funding: This project was supported by the Roots, Tubers and Bananas (RTB) Research Program of the Consultative Group on International Agricultural Research (CGIAR).

Design descriptions: The purpose of this dataset is to broadly and openly share geographic distribution data for the cassava whitefly complex and their associated parasitoids and hyperparasitoids. Prior to this contribution, no records were found of these

arthropod species in cassava at the Global Biodiversity Information Facility (2015). To bridge this gap, this paper submits 1,311 distribution records (whiteflies: 841; parasitoids: 466; hyperparasitoids: 4), documented by the International Center for Tropical Agriculture (CIAT) between 1975 and 2012. More than half of these records correspond to specimens preserved at CIAT's Arthropod Reference Collection (CIAT-ARC). Most of the whitefly records correspond to *Aleurotrachelus socialis* Bondar and *Bemisia tuberculata* Bondar (Fig. 1A). In turn, most parasitoid records belong to *Encarsia hispida* De Santis, *Encarsia* sp. and *E. sophia* (Girault & Dodd) (Fig. 1B). This dataset should be of particular interest to whitefly biologists, cassava entomologists and national plant protection organizations (NPPOs) in tropical countries.

Taxonomic coverage

General taxonomic coverage description

Most records were identified to the species level (whiteflies: 97%; parasitoids and hyperparasitoids: 73%) by expert entomologists. Experts identifying more than 20 records were Gregory A. Evans, María del Pilar Hernández, Sueo Nakahara and Louise M. Russell. Whitefly records belong to nine genera and eleven species (Table 1), whereas parasitoid records belong to eight genera and 14 species (Table 1). The dataset also includes four records of the genus *Signiphora* (Table 1), considered a genus of whitefly hyperparasitoids (Evans 2007).

Taxonomic ranks

Kingdom: Animalia
Phylum: Arthropoda
Class: Insecta
Order: Hemiptera, Hymenoptera
Family: Aleyrodidae, Aphelinidae, Ceraphronidae, Encyrtidae, Eulophidae, Platygastridae, Signiphoridae
Genus: *Aleuroctonus*, *Aleurodicus*, *Aleuroglandulus*, *Aleuronudus*, *Aleurothrixus*, *Aleurotrachelus*, *Amitus*, *Anagyrus*, *Aphanogmus*, *Bemisia*, *Encarsia*, *Eretmocerus*, *Euderomphale*, *Metaphycus*, *Paraleyrodes*, *Signiphora*, *Tetraleurodes*, *Trialeurodes*
Species: *Aleuroctonus vittatus* (Dozier), *Aleurodicus dispersus* Russell, *Aleurodicus flavus* Hempel, *Aleuroglandulus subtilis* Bondar, *Aleurothrixus aepim* (Goldi), *Aleurotrachelus socialis* Bondar, *Amitus fuscipennis* MacGown & Nebeker, *Amitus macgowni* Evans & Castillo, *Bemisia tabaci* (Gennadius), *Bemisia tuberculata* Bondar, *Encarsia americana* (DeBach & Rose), *Encarsia bellotti* Evans & Castillo, *Encarsia cubensis* Gahan, *Encarsia desantisis* Viggiani, *Encarsia guadeloupae* Viggiani, *Encarsia hispida* De Santis, *Encarsia luteola* Howard, *Encarsia nigricephala* Dozier,

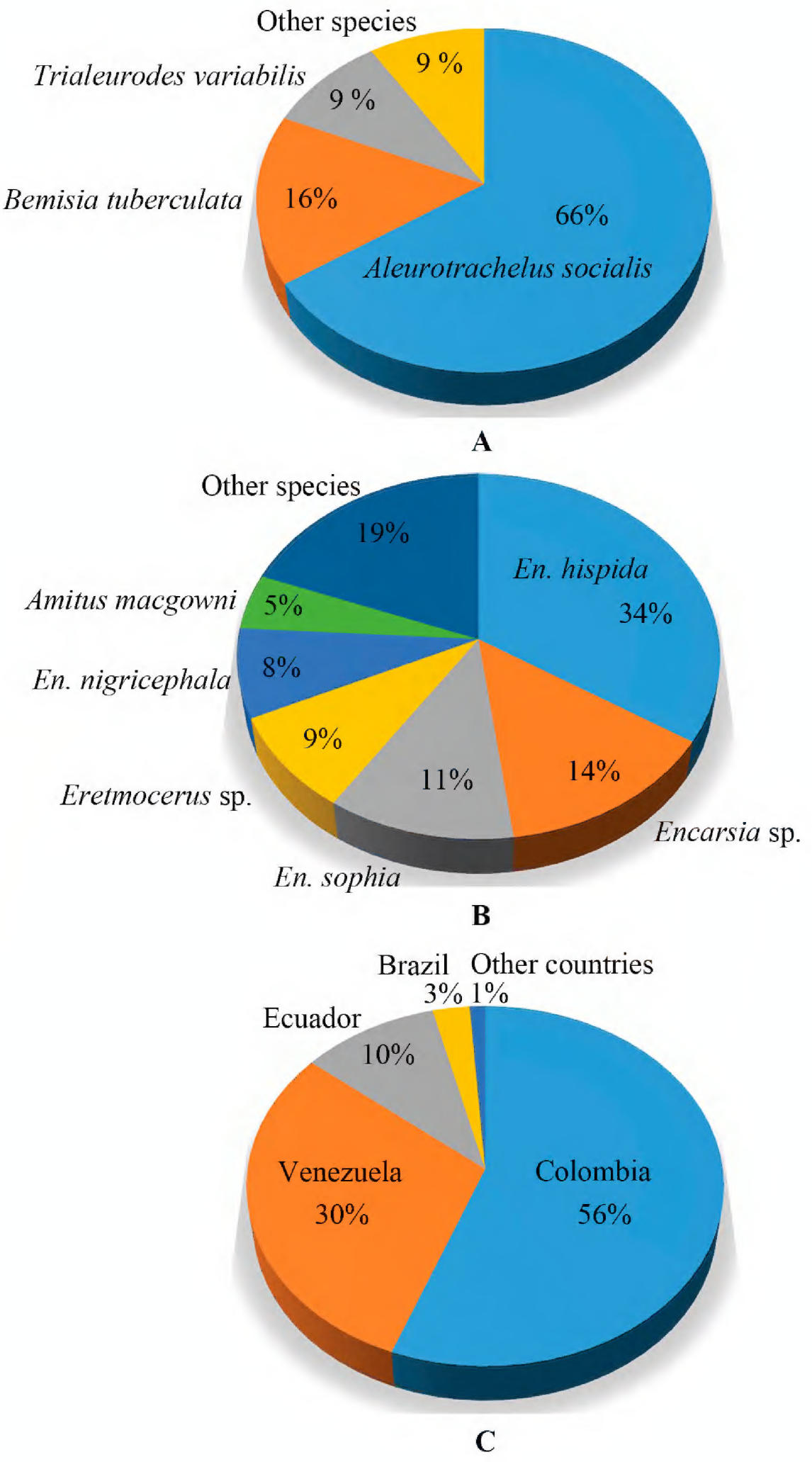

Figure 1. Percentage of occurrence records by Neotropical whitefly species (**A**), by parasitoids (**B**) and by country origin (**C**) in the CIAT's Arthropod Reference Collection database (N=1,311).

Table 1. Neotropical cassava whiteflies or parasitoids associated with the parasitoids and hyperparasitoids of the CIAT's Arthropod Reference Collection database. Ad: *Aleurodicus dispersus*, Asp: *Aleurodicus* sp., Asu: *Aleuroglandulus subtilis*, Am: *Aleuronudus melzeri*, Aa: *Aleurothrixus aepim*, As: *Aleurotrachelus socialis*, Alsp. *Aleurotrachelus* sp., Bt: *Bemisia tabaci*, Btu: *Bemisia tuberculate*, Bsp: *Bemisia* sp., Tvap: *Trialeurodes vaporariorum*, Tsp: *Tetraleurodes* sp., Tva: *Trialeurodes variabilis*, Trsp: *Trialeurodes* sp., Eh: *Encarsia hispida*, n: number of host for each species.

Hymenoptera		Whitefly species														Eh	n
Family	**Species**	**Ad**	**Asp**	**Asu**	**Am**	**Aa**	**As**	**Alsp**	**Bt**	**Btu**	**Bsp**	**Tvap**	**Tsp**	**Tva**	**Trsp**		
Aphelinidae	*Encarsia* sp.		×	×	×		×		×	×				×	×		8
	Encarsia americana						×						×				2
	Encarsia bellottii						×							×	×		3
	Encarsia cubensis						×										1
	Encarsia desantisi			×													1
	Encarsia guadeloupae			×													1
	Encarsia hispida						×	×	×	×			×	×	×		7
	Encarsia luteola								×								1
	Encarsia nigricephala								×								1
	Encarsia pergandiella									×		×		×			3
	Encarsia sophia						×		×	×	×						4
	Encarsia tabacivora								×						×		2
	Eretmocerus sp.						×		×	×				×			4
Ceraphronidae	*Aphanogmus* sp.						×										1
Encyrtidae	*Anagyrus* sp.					×											1
	Metaphycus sp.						×			×							2
Eulophidae	*Aleuroctonus vittatus*	×															1
	Euderomphale sp.						×			×							2
Platygastridae	*Amitus* sp.						×			×				×			3
	Amitus fuscipennis												×				1
	Amitus macgowni		×				×	×									3
Signiphoridae	*Signiphora* sp.						×[1]									×	2
	Signiphora aleyrodis									×[1]							1
Total species by host		1	2	3	1	1	13	2	7	9	1	1	3	6	4	1	

[1] This is a hyperparasitoid case (see taxonomic coverage).

Encarsia pergandiella Howard, *Encarsia sophia* (Girault & Dodd), *Encarsia tabacivora* Viggiani, *Signiphora aleyrodis* Ashmead, *Tetraleurodes ursorum* (Cockerell), *Trialeurodes similis* Russell, *Trialeurodes vaporariorum* (Westwood), *Trialeurodes variabilis* (Quaintance)

Common name: whitefly (for Aleyrodidae)

Spatial coverage

General spatial coverage: Most of the distribution records belong to South America (Brazil, Colombia, Ecuador and Venezuela) and Central America (El Salvador, Guatemala, Honduras, Nicaragua and Panama). Colombia and Venezuela are the best represented countries, followed by Brazil and Ecuador (Fig. 1C). There are also seven records of whiteflies from Asia (Lao and Thailand). The distribution maps of principal whiteflies and their parasitoids are shown in Figure 2.

Coordinates: 17.95751 and -25.38936 latitude; -89.86917 and 104.72175 longitude

Temporal coverage: 1975-2012

Natural collections descriptions

Collection name: CIAT's Arthropod Reference Collection (CIATARC)

Specimen preservation method: Specimens are preserved in microslides (whiteflies, parasitoids and hyperparasitoids), tissue beds on dried vials (parasitoids), 70% ethyl alcohol (parasitoids and hyperparasitoids), or in 35 mm plastic slide mounts (whiteflies). These samples are deposited within cabinet drawers maintained at 21.0 ± 0.4 °C and 47.6 ± 8.6% relative humidity. They are sorted numerically by species and country of origin.

Curatorial unit: 1601 with an uncertainty of 0.

Methods

Method step description: The dataset integrates two data flows: observational records and specimen-based records, identified either to genus or to species. The former were digitized from field diagnostic forms recorded by personnel extensively trained in identification of whiteflies and parasitoids identification. These identifications, however, were likely conducted on site without mounting and preserving samples. Alternatively, these observations may correspond to properly-mounted but lost specimens. In either case, we are significantly confident on these identifications due to relatively clear macroscopic differences in our focal taxa (Caballero 1994, Fernández and Sharkey 2006). Still, conservative users of our database may prefer to rely only on genus-level

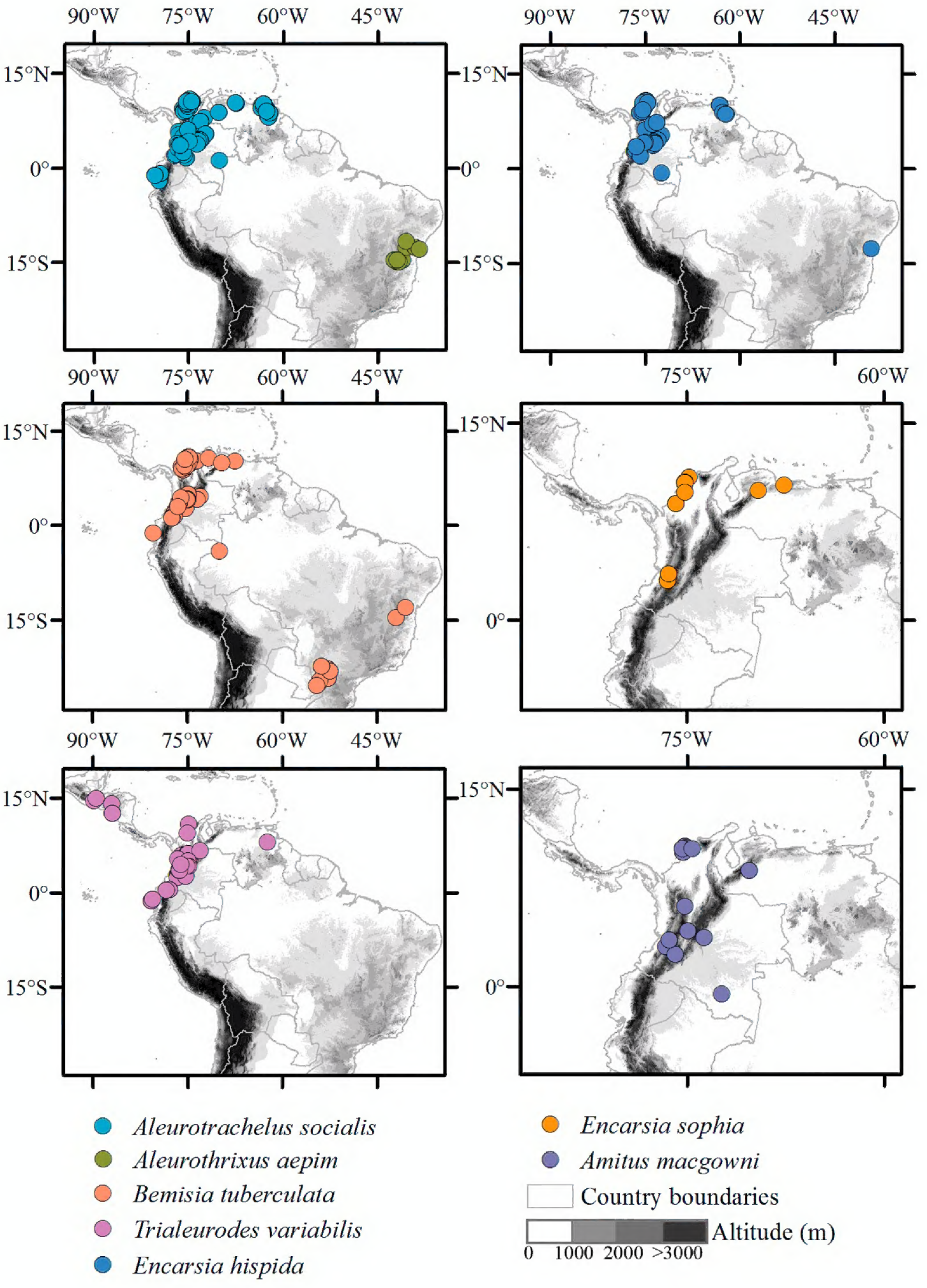

Figure 2. Geographic distributions of Neotropical cassava whitefly species (maps on the left) and their associated parasitoid species (maps on the right) in the CIAT's Arthropod Reference Collection database.

identifications of these records. On the other hand, the specimen-based records belong to verifiable samples properly-preserved at CIATARC. Guidelines of Martin (1987) and Hodges and Evans (2005) were followed for whitefly slide preparations, and Noyes (1982) for parasitoid and hyperparasitoid preparations. Unique accession numbers were assigned to all records.

All biodiversity data available (i.e. specimen, species identification, name of determiner, sex, locality, date, habitat, host, collector and observations) were digitized in a Microsoft Excel 2010 spreadsheet adopting the Darwin Core Archive format v1.2 (Wieczorek et al. 2012). We updated locality fields (e.g., district, municipality) using the most current names and classifications of administrative divisions used by each country (e.g. http://www.dane.gov.co/Divipola/ for Colombia, http://www.inec.gob.ec/estadisticas/?option=com_content&view=article&id=80 for Ecuador, etc. [accessed 14 November 2014]). Based on their locality names, we then geocoded the records using Google Maps (https://maps.google.com/), Geolocate (http://www.museum.tulane.edu/geolocate/), GeoNames (http://www.geonames.org/) or with georeference indicated in scientific articles (Calderón et al. 1994, Eiszner et al. 1996, Navia Estrada et al. 2006, Cuadros et al. 2011, Gutiérrez R. et al. 2011). GPS coordinates were converted to decimal degrees. The dataset with metadata was uploaded to the Integrated Publishing Toolkit (IPT) of the Colombia node of Global Biodiversity Information Facility (GBIF) (http://www.gbif.org/dataset/c6f4c2de-3b71-4ebd-9c98-c21537548f07).

Sampling description: The records in the dataset have been documented in three ways:

1) Records from CIAT's initial field explorations to document pests in cassava (CIAT 1974, 1985; 0.7% records, between 1975-1989).
2) Records documented during the "Biological Control of Whiteflies by Indigenous Natural Enemies for Major Food Crops in the Neotropics Projects" and participation in "Global Whitefly IPM Project" led by CIAT, Instituto Nacional de Investigaciones Agropecuarias (INIAP), Centro Nacional de Investigaciones Agropecuarias (CENIAP), Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), The University of Florida and Corporación Colombiana de Investigacion Agropecuaria (Corpoica) (CIAT 1995, 2002, Bellotti et al. 1996, 1999, 2000, 2005, Bellotti 2001, Arias and Bellotti 2002, CIAT et al. 1998, Castillo 1996, López-Ávila et al. 2001, Hernandez and Bellotti 2002, Holguín et al. 2002, Hernández et al. 2004, 2009, Trujillo et al. 2004, Herrera et al. 2006; 95.7% records, between 1990-2007).
3 Records from other sources; including field inspections and collections conducted during routine farm visits by CIAT personnel, and specimens submitted to CIATARC by fellow institutions and researchers (Adriano Muñoz and Gerardino Perez, pers. comm. November 29, 2014; 2.6% records between 2008-2012).

The records resulted from one of two sampling methods. The first method was designed to identify parasitoids associated with dominant whitefly species on farmers' fields. One middle-canopy leaf infested with whiteflies was collected from each of 40-100 randomly-selected plants per field. A disc of 2.54 cm^2 was excised from the

leaf lobe with the highest density of whitefly pupae. The single most abundant whitefly species per disc was identified and individuals not belonging to that species were eliminated by puncturing them with a needle. The disc samples were then individually placed in 25-ml glass vials and held for 2–3 days at 24.5 ± 4 °C and 70 ± 5% relative humidity under laboratory conditions until parasitoids emerged (Bellotti et al. 1999, 2000, Trujillo et al. 2004). The second method corresponds to opportunistic collections during routine farm visits by CIAT personnel, when leaves infested with whitefly pupae would be collected in vials with 70% alcohol and submitted to the CIATARC for subsequent identification (Herrera et al. 2006). All formally-submitted samples were mounted and are preserved at the CIATARC. The database does not indicate which sampling method was used for each record.

Quality control description: Record validation and cleaning was incorporated at several steps of the documentation process, following guideless by Chapman (2005a, b). The scientific names on labels were checked with a taxonomic thesaurus developed by Aymer Andrés Vásquez-Ordóñez, Juan David Escobar-Prieto and Dario Paz-Jojoa. This thesaurus compiled all known synonyms and spelling variants of the scientific names used for our focal species. Scientific names were assigned in accordance to current taxonomic trends (whiteflies: Evans 2008; parasitoids and hyperparasitoids: Woolley 1988, Polaszek et al. 2004, Evans 2007, Johnson 2007, 2015, Noyes 2014; associated plants: Tropicos 2014). Geographic coordinates were verified using the "Check Coordinates" function in DIVA-GIS (Hitmans et al. 2001). For this last step, we relied on the Global Administrative Unit Layers (GAUL) shape file developed by the Food and Agriculture Organization of the United Nations (FAO 2015), and official shape of administrative division of Brazil, Colombia, Ecuador and Venezuela (IBGE 2007, INEC 2011, SIGOT 2011, IVIC 2007).

Datasets

Dataset description

Object name: Darwin Core Archive cassava whiteflies complex and their associated parasitoids and hyperparasitoids: data of the CIAT's Arthropod Reference Collection of International Center for Tropical Agriculture (CIAT).
Character encoding: UTF-8
Format name: Darwin Core Archive format
Format version: 1.0
Distribution: http://www.gbif.org/dataset/c6f4c2de-3b71-4ebd-9c98-c21537548f07
Publication date of data: 2015-05-15
Language: English
Licenses of use: This dataset [Neotropical cassava whiteflies complex and their associated parasitoids and hyperparasitoids of CIAT's Arthropod Reference Collection (CIATARC)] is made available under the Creative Commons Zero (CC0) 1.0.

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References

Aliaga J (2012) Presencia de *Trialeurodes variabilis* (Quanintance, 1900) y su parasitoide *Eretmocerus eremicus* Rose & Zolnerowich en cultivos de yuca *Manihot esculenta* Crantz en Supe-Barranca, Lima-Perú. Revista Peruana de Entomología 47(1): 12–14.

Arias B, Bellotti AC (2002) Biological control of cassava whiteflies; surveys of cassava plantations in Yopal, Casanare, Colombia for parasitoid natural enemies. In: CIAT (Ed.) Project PE-1: Integrated Pest and Disease Management in Major Agroecosytems in the Americas. Annual Report 2002. Centro Internacional de Agricultura Tropical, CIAT, Cali, Colombia, 13 pp.

Bellotti AC (2001) Identification, Quantification and Analysis of Major Arthropod Complexes. In: CIAT (Ed.) Project PE-1: Integrated Pest and Disease Management in Major Agroecosytems in the Americas. Annual Report 2001. Centro Internacional de Agricultura Tropical, CIAT, Cali, Colombia, 211 pp.

Bellotti A, Alvarez E, Calvert L, Smith L, Lapointe S, Ospina B, El-Sharkawy M, Muller K, Howeler R, Riis L, Bertschy C (1996) Project 7: Integrated Cassava Crop Management in Major Agroecosystems of Latin America and Asia. Annual Report 1996. Centro Internacional de Agricultura Tropical, CIAT, Cali, Colombia, 60 pp.

Bellotti AC, Alvarez E, Calvert L, Calatayud PA, Anderson P, Buruchara R, Ampofo K (1999) Project PE-1: Integrated Pest Management in Major Agroecosytems in the Americas. Centro Internacional de Agricultura Tropical, CIAT, Cali, Colombia, 136 pp.

Bellotti AC, Calatayud PA, Dorn B, Alvarez E, Peck D, Calvert L, Buruchara R, Ampofo K, Anderson P (2000) Project PE-1: Integrated Pest and Disease Management in Major Agroecosytems in the Americas. Annual Report 2000. Centro Internacional de Agricultura Tropical, CIAT, Cali, Colombia, 190 pp.

Bellotti A, Peña J, Arias B, Guerrero JM, Trujillo H, Holguín C, Ortega A (2005) Biological Control of Whiteflies by Indigenous Natural Enemies for Major Food Crops in the Neotropics. Chapter 5.2. In: Anderson PK, Morales FJ (Eds) Whitefly and Whitefly-borne Viruses in the Tropics: Building a Knowledge Base for Global Action. Centro Internacional de Agricultura Tropical, CIAT, Cali, Colombia, 313–323.

Caballero R (1994) Clave de campo para inmaduros de moscas blancas de Centroamérica (Homoptera: Aleyrodidae). CEIBA 35(1): 47–51.

Castillo JA (1996) Moscas blancas (Homoptera: Aleyrodidae) y sus enemigos naturales sobre cultivos de yuca (*Manihot esculenta* Crants) en Colombia. MSc thesis, Universidad del Valle, Cali, Colombia.

Calderón LF, Dardón D, Salguero V (1994) Efecto de coberturas del suelo sobre poblaciones de mosca blanca (*Bemisia tabaci*) y acolochamiento en tomate. In: Dardon Avila DE, Salguero Nava V (Eds) Proyecto MIP-ICTA-CATIE-ARF. Manejo Integrado de la mosca blanca en tomate. Fase II: 1992–1993. CIVBA, Guatemala, 45–54.

Chapman AD (2005a) Principles and Methods of Data Cleaning – Primary Species and Species-Occurrence Data, version 1.0. Global Biodiversity Information Facility, Copenhagen, 75 pp.

Chapman AD (2005b) Principles of Data Quality, version 1.0. Global Biodiversity Information Facility, Copenhagen, 61 pp.

CIAT (1974) Informe Anual CIAT 1974. Centro Internacional de Agricultura Tropical, CIAT, Cali, Colombia, 286 pp.

CIAT (1985) Annual Report 1985. Cassava Program. Working Document No. 38. Centro Internacional de Agricultura Tropical, CIAT, Cali, Colombia, 371 pp.

CIAT (1995) Annual Report 1994–1995. Cassava Program. Working Document No. 168. Centro Internacional de Agricultura Tropical, CIAT, Cali, Colombia, 611 pp.

CIAT (2002) Project PE-1: Integrated Pest and Disease Management in Major Agroecosytems in the Americas. Annual Report 2002. Centro Internacional de Agricultura Tropical, CIAT, Cali, Colombia, 264 pp.

CIAT, ITTA, EMBRAPA/CNPMF (1998) Ecologically Sustainable Cassava Plant Protection in South America and Africa: An Environmentally Sound Approach.1997 Annual report of Activities in South America. Centro International de Agricultura Tropical, CIAT; The International Institute for Tropical Agriculture, ITTA; Empresa Brasileira de Pesquisa Agropecuaria, Centro Nacional de Pesquisa de Mandioca e Frutas Tropicais, Embrapa/CNPMF, 115 pp.

Cuadros GGA, Gómez SR, Rodríguez LNF (2011) Asociación simbiótica entre hongos micorrízicos arbusculares y el sistema radicular de plántulas de cacao (*Theobroma cacao* L.): efecto de la formononetina y la disponibilidad de fósforo en el suelo. Revista Corpoica Ciencia y Tecnología Agropecuaria 12(1): 77–85.

Eiszner H, Blandón V, Pohlan J (1996) Rotación de Cultivos en Algodón-Impactos Agronómicos y Ecológicos. Der Tropenladwir, Beiträge zur tropischen Landwirtschaft und Veterinärmedizin, 97: 75–83.

da Silva Alonso R, Racca-Filho F, Florêncio de Lima A (2012) Occurrences of Whiteflies (Hemiptera: Aleyrodidae) on Cassava (*Manihot esculenta* Crantz) Crops Under Field Conditions in the State of Rio de Janeiro, Brazil. EntomoBrasilis 5(1): 78–79. doi: 10.12741/ebrasilis.v5i1.170

Evans GA (2007) Parasitoids (Hymenoptera) associated with whiteflies (Aleyrodidae) of the world. http://www.sel.barc.usda.gov:8080/1WF/parasitoidcatalog.pdf [accessed 04 May 2015]

Evans GA (2008) The whiteflies (Hemiptera: Aleyrodidae) of the world and their host plants and natural enemies. http://www.sel.barc.usda.gov:8080/1WF/World-Whitefly-Catalog.pdf; http://keys.lucidcentral.org/keys/v3/whitefly/PDF_PwP%20ETC/world-whitefly-catalog-Evans.pdf [accessed 04 May 2015]

FAO (2015) Global Administrative Unit Layers (GAUL). http://www.fao.org/geonetwork/srv/en/metadata.show?id=12691 [accessed 14 November 2013]

Fernández F, Sharkey MJ (2006) Introducción a los Hymenoptera de la Región Neotropical. Sociedad Colombiana de Entomología y Universidad Nacional de Colombia, Bogotá, Colombia, 894 pp.

Global Biodiversity Information Facility (2015) http://www.gbif.org/ [accessed 04 May 2015]

Gutiérrez RM, Gómez SR, Rodríguez LNF (2011) Comportamiento del crecimiento de plántulas de cacao (*Theobroma cacao* L.), en vivero, sembrada en diferentes volúmenes de sustrato. Revista Corpoica Ciencia y Tecnología Agropecuaria 12(1): 33–42.

Hernández MP, Bellotti AC (2002) Arthropod taxonomic activities on cassava and other crops Activity 1. In: CIAT (Ed.) Project PE-1: Integrated Pest and Disease Management in Major Agroecosytems in the Americas. Annual Report 2002. Centro Internacional de Agricultura Tropical, CIAT, Cali, Colombia, 1–5.

Hernández MP, Guerrero JM, Bellotti A (2004) Arthropod taxonomic activities on CIAT commodity crops. Cassava Entomology, Activity 1. In: CIAT (Ed.) Project PE-1: Integrated Pest and Disease Management in Major Agroecosytems. Project PE-1-Annual Report 2004. Centro Internacional de Agricultura Tropical, CIAT, Cali, Colombia, 1–5.

Hernández M, Arias B, Bellotti A (2009) Whiteflies and parasitoides associated with the cassava crop in South America. http://ciat-library.ciat.cgiar.org:8080/jspui/bitstream/123456789/2023/1/whitefliesparasitoides.pdf [accessed 10 june 2015]

Herrera CJ, Holguin C, Muñoz A, Bellotti AC (2006) Integrated management of whiteflies (Homoptera:Aleyrodidae) on cassava. Activity 4.2. In: CIAT (Ed.) Crop and Agroecosystem Health Management, Project PE-1-Annual Report 2006. Centro Internacional de Agricultura Tropical, CIAT, Cali, Colombia, 210–219.

Hitmans RJ, Guarino L, Cruz M, Rojas E (2001) Computer tools for spatial analysis of plant genetic resources data: 1. Diva-Gis. Plant Genetic Resources Newsletter 127: 15–19.

Hodges GS, Evans GA (2005) An identification guide to the whiteflies (Hemiptera: Aleyrodidae) of the Southeastern United States. Florida Entomologist 88(4): 518–534. doi: 10.1653/0015-4040(2005)88[518:AIGTTW]2.0.CO;2

Holguín C, Muñoz A, Mendoza CE, Bellotti AC (2002) The establishment of an IPM program for cassava whiteflies in Valle del Cauca y Cauca departments in Colombia. In: CIAT (Ed.) Project PE-1: Integrated Pest and Disease Management in Major Agroecosytems in the Americas. Annual Report 2002. Centro Internacional de Agricultura Tropical, CIAT, Cali, Colombia, 14–24.

IBGE (2000) Municipio 2007. Instituto Brasileiro de Geografía e Estatística. ftp://geoftp.ibge.gov.br/malhas_digitais/municipio_2007/escala_2500mil/proj_geografica_sirgas2000/brasil/55mu2500gsr.zip [accessed 04 May 2015]

INEC (2011) División Política Administrativa Ecuador-Nacional por Parroquias. http://www.inec.gob.ec/estadisticas//?option=com_content&view=article&id=299 [accessed 04 May 2015]

IVIC (2007) Mapas de Venezuela. División de Municipios. http://www.ivic.gob.ve/ecologia/lpydv/internas/?mod=galeriaMapas.php [accessed 04 May 2015]

Johnson NF (2007) Hymenoptera Name Server. http://osuc.biosci.ohio-state.edu/hymDB/nomenclator.home_page [accessed 04 May 2015]

Johnson NF (2015) Platygastroidea. http://osuc.biosci.ohio-state.edu/hymDB/eol_scelionidae.home [accessed 04 May 2015]

Lebot V (2009) Tropical root and tuber crops: cassava, sweet potato, yams and aroids. CABI, Wallingford, 433 pp.

López-Ávila A, Cardona Mejía C, García González J, Rendón F, Hernández P (2001) Reconocimiento e identificación de enemigos naturales de moscas blancas (Homoptera: Aleyrodidae) en Colombia y Ecuador. Revista de la Sociedad Colombiana de Entomología, Socolen 27(3–4): 137–141.

Martin JH (1987) An identification guide to common whitefly pest species of the world (Homoptera: Aleyrodidae). Tropical Pest Management 33(4): 298–322. doi: 10.1080/09670878709371174

Navia Estrada J, Barrios E, Sánchez M (2006) Efecto de aportes superficiales de biomasa vegetal en la temperatura, humedad y dinámica de nemátodos en el suelo en época seca en Santander de Quilichao (Departamento del Cauca). Acta Agronómica 55(2): 9–14.

Noyes JS (1982) Collecting and preserving chalcid wasp (Hymenoptera: Chalcidoidea). Journal of Natural History 16(3): 315–334. doi: 10.1080/00222938200770261

Noyes JS (2014) Universal Chalcidoidea Database. World Wide Web electronic publication. http://www.nhm.ac.uk/chalcidoids [accessed 04 May 2015]

Plantwise (2015) Pest distribution maps. CABI Publishin, Wallingford, UK. http://www.plantwise.org/KnowledgeBank/PWMap.aspx [accessed 04 May 2015]

Pietrowski V, Rheinheimer AR, Monasani Miranda A, Gonçalves da Silva Wengrat AP, Ricardo Barilli D (2014) Ocorrência de *Aleurothrixus aepim* (Goeldi, 1886) em mandioca na região Oeste do Paraná. Arquivos do Instituto Biológico 81(2): 186–188. doi: 10.1590/1808-1657000242012

Polaszek A, Manzari S, Quicke DLJ (2004) Morphological and molecular taxonomic analysis of the *Encarsia meritoria* species-complex (Hymenoptera, Aphelinidae), parasitoids of whiteflies (Hemiptera, Aleyrodidae) of economic importance. Zoologica Scripta 33(5): 403–421. doi: 10.1111/j.0300-3256.2004.00161.x

SIGOT (2011) Mapa Topográfico de la República de Colombia Escala 1:500000. http://sigotn.igac.gov.co/sigotn/frames_metadato.aspx?id=6923782 [accessed 04 May 2015]

Silva AS, Mota TA, Fernandez MG, Kassab SO (2014) Sequential sampling of *Bemisia tuberculata* (Bondar, 1923) (Hemiptera: Aleyrodidae) on cassava crop. Anais da Academia Brasileira de Ciências 86(2): 889–896. doi: 10.1590/0001-37652014117212

Tropicos (2014) Tropicos.org. Missouri Botanical Garden. http://www.tropicos.org [accessed 04 May 2015]

Trujillo HE, Arias B, Guerrero JM, Hernandez P, Bellotti A, Peña JE (2004) Survey of parasitoids of whiteflies (Homoptera: Aleyrodidae) in cassava growing regions of Colombia and Ecuador. Florida Entomologist 57(3): 268–273. doi: 10.1653/0015-4040(2004)087[0268:SOPOWH]2.0.CO;2

Wieczorek J, Bloom D, Guralnick R, Blum S, Döring M, Giovanni R, Tobertson T, Vieglais D (2012) Darwin Core: An Evolving Community-Developed Biodiversity Data Standard. PLoS ONE 7(1): e29715. doi: 10.1371/journal.pone.0029715

Wolley JB (1988) Phylogeny and classification of the Signiphoridae (Hymenoptera: Chalcidoidea). Systematics Entomology 13: 465–501. doi: 10.1111/j.1365-3113.1988.tb00256.x